

USE PLANTS SPECIES OF *TYPHA ANGUSTIFOLIA* L. IN THE RESTORATION OF WETLAND ECOSYSTEMS IN AGRICULTURE LANDSCAPE

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ABSTRACT

Our environment is significantly impaired due to pollution and overexploitation of natural resources. All natural ecosystems have been greatly damaged. Restoring the natural functions of ecosystems is a priority for now. Wetland macrophytes, such as higher plants, play an important role in the recovery process, particularly in terms of biological treatment of water run-off from agricultural land. The phytoremediation is the main method of recovery in this context. Phytoremediation is ability of plants to receive and accumulate chemicals from environmental pollution and to improve its properties. The goal of paper is to verify the response of one species of wetland macrophytes *Typha angustifolia* L. on eutrophic conditions and to assess their use in the restoration as phytoremediants. To meet the target, container experiments were conducted in greenhouse conditions with a differentiated mineral nutrition. Plants species *Typha angustifolia* L. is able to accumulate the major macro elements (nitrogen, phosphorus, potassium) and use them to create the above-ground and below-ground biomass. *Typha angustifolia* L. is also hyperaccumulator of Zinc (Zn). It has high resilience and ability to vegetative propagation. *Typha angustifolia* L. forms a large amount of biomass in the eutrophic and oligotrophic conditions and therefore has a secondary potential as an alternative energy source.

1. INTRODUCTION

Ecosystem damage is caused may be due to several disturbances, which are usually reinforced or caused by man. Human society, particularly in developed countries, recognizes the need for an active recovery (rehabilitation, revitalization, etc.) of the man destroyed or degraded ecosystems, communities or population.

Restoration is in a sense of counterpart protection (conservation). If in the country (ecosystem) is no longer the preservation is the more appropriate method of restoration (Kovář, 2006).

As the Samways reports (2000), restoration from biocentric terms should enable restoration of ecological integrity and natural succession and evolutionary possibilities. Chapin et al. (2000) define the objectives of restoration focused on restoration of ecological functions in terms of energy flow and materials through a set of biotic and abiotic components of ecosystems. Cudlín et al. (2001) believes that the reconstruction should be aimed at improving the ecological stability.

Bioremediation of wetland macrophytes skills

Certain forms of heavy metals in soil and water create natural background associated mostly with the weathering of rocks. Critical proportion of the heavy metals in soil and water come from human activity (Dercová et al. 2005). The restoration methods integrate advanced bioremediation processes that belong to biotechnology. Bioremediation is the use of metabolic activity of "living" organisms to remove contaminants from the environment. Phytoremediation is using of plants to remediation of the environmental pollution.

Phytoremediation has been developed for a wide range of applications not only inorganic pollutants, but for organic pollutants too. The issue of remediation, bioremediation and phytoremediation to deal with a number of authors as an example and recommended works Agathos, Reineke, 2000; Vise et al., 2000; Swindoll, Stahl, 2000; Jester et al., 2003; Prasad et al., 2006; Willey, 2007.

Some plants, known as hyperaccumulators, accumulate metals in high quantities. The concentration of heavy metals in biomass of these plants exceeded by one to two times of values found in normal plants. It is more than 1 mg of metal in 1 g of dry matter (Dercová et al., 2005).

Wetland macrophytes such as *Typha angustifolia* L., which we used in our experiments, is one of the dominant species of eutrophic wetlands. The anatomical, morphological and physiological characteristics predetermine it to use as phytoremediant in the processes of restoration in agricultural country.

Studies and the subsequent practical use in biological (root) wastewater treatment plants best document the bioremediation ability of wetland macrophytes.

Typha angustifolia L. is suitable for treatment of waste water with high content of organic matter.

The goal of this paper is to verify the response of plant wetland species *Typha angustifolia* L. to eutrophic conditions and identify its role in the restoration process as phytoremediant.

2. MATERIAL AND METHODS

Typha angustifolia L. (Fig. 1) is able to grow in different environmental conditions and it is propagated mainly by vegetative ways. This species is considered particularly to well suit wetland habitats.



Figure 1 *Typha angustifolia* L. in wetland biotope in the agriculture landscape (Photo: Kotrla, 2007)

This species do well a wide temperature ranged from 10 to 30 °C, seeds germinate after 3 days at 15 to 37 °C, the speed of germination is influenced by many factors. It grows in the range of pH 4-10 (Cronkite, Fennessy, 2001).

Typha angustifolia L. is a wetland species, often located on the banks of ponds and water channels. It can be seen also in shallow waters where the water level ranges from 5-10 cm, in mud environment and wet meadows.

It is expanded in the altitude up to 350 m especially, but it can be located up to 500 m above sea level. This species is situated in lowland areas in particular. Its presence is also limited by slopes. It occurs in inclination from 35 to 40°. It is expanded almost throughout Europe, North Africa and Asia.

Interaction effects of factors (pH, concentration of heavy metals) on the accumulation and distribution of elements (nitrogen – N, phosphorus – P, potassium - K, zinc – Zn) in biomass of this species were followed in terms of container experiment in greenhouse conditions. We created variants (variant A, B, C, D and E) with the basic (variant A) and escalation concentration of fundamental elements (N, P, K) (variants B to D) and heavy metal zinc (Zn) (variant E). We studied the contents of N, P, K and Zn in aboveground and underground organs. We cultivated plants in a nutrient solution, to verify the ability to accumulate minerals by *Typha angustifolia* L. (Table 1).

Table 1 The composition of the basic nutrient solution, according to Hoagland (1939)

| Salt | Basic solution in g.l ⁻¹ |
|-----------------------------------|-------------------------------------|
| Ca(NO ₃) ₂ | 0,821 |
| KNO ₃ | 0,506 |
| KH ₂ PO ₄ | 0,136 |
| MgSO ₄ | 0,320 |

We planted the plants in containers with double bottom with a capacity of 15 liters to medium sand – fine gravel in a 1:1 ratio (Fig. 2).



Figure 2 The scheme of experimental plant cultivation container

The control variant was without essential nutrients added to the amount represented by the nutrient content of the composition of 5 l of the basic humidification (N - 780 mg, P - 35 mg, C - 975 mg, Zn - 6 mg) (Variant A). In variants B and E three times the concentration of N, P, K and Zn were used. Variants of experiment are shown in Table 2.

Table 2 Variants of experiment – nutrient treatment

| Variant name | Net amount of nutrients in the container in mg | | | |
|--------------|--|-----|------|----|
| | N | P | K | Zn |
| Variant A | 780 | 35 | 975 | 6 |
| Variant B | 3900 | 35 | 975 | 6 |
| Variant C | 780 | 105 | 975 | 6 |
| Variant D | 780 | 35 | 4875 | 6 |
| Variant E | 780 | 35 | 975 | 30 |

Legend: N – nitrogen, P – phosphorus, K – potassium, Zn – zinc

3. RESULTS AND DISCUSSION

The concentration of nutrients in the environment (including water) is not the actual picture elements contained in the organs of plants. We analyzed the content of elements in the aboveground and underground organs. In our experiments, we focused on the accumulation ability of the species *Typha angustifolia* L.. We have confirmed that the increased number of elements affect the activity of plants. In biomass increased the accumulation of elements (Fig. 3, 4, 5).

The percentage of the amount of nitrogen taken by plants from the total amount in the substrate showing to force the amount absorbed N to produce biomass. In the control variant, underground organs accumulated 19.5% and aboveground organs 33.5% from the total N in the substrate. In variant B (3N) accumulated of underground organs (28.24%) and weight of biomass was increased by 24.60%. Aboveground organs accumulated 40.38% of total N in the environment, increasing their weight of biomass by 23.37%.

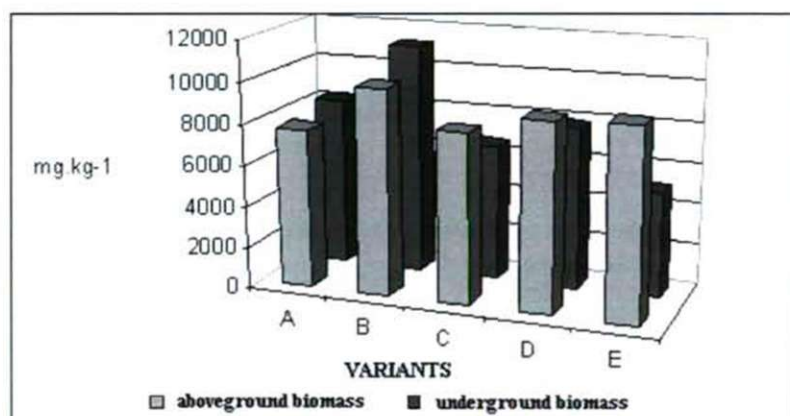


Figure 3 The amount of nitrogen (mg N.kg^{-1} dry weight) in aboveground and underground organs of *Typha angustifolia* L.

The percentage of the amount of phosphorus received by plants from the total amount in the substrate, confirmed that the increased P content in the substrate plants take the increased amount of this mineral. In the control variant, underground organs accumulated 21.4% and aboveground 18.5% from the total P in the substrate. The variant C (3P) increased accumulation of underground organs (22.5%) and aboveground organs accumulated 30.05% from total P in the environment.

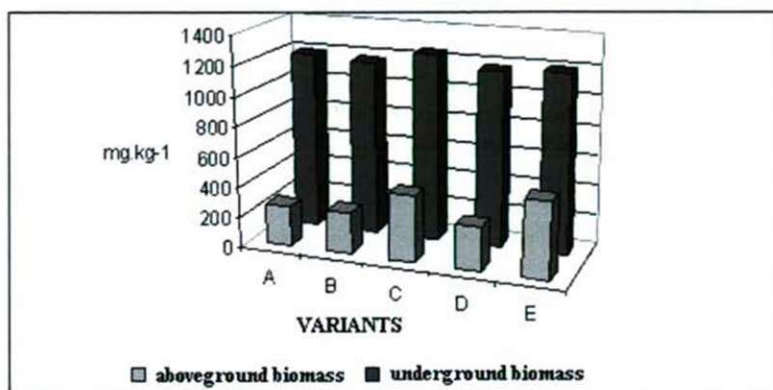


Figure 4 The amount of phosphorus (mg P.kg⁻¹ dry weight) in aboveground and underground organs of *Typha angustifolia* L.

The percentage of received potassium by plants from the total amount of K in the substrate, confirmed that the increased content in the substrate, increased its revenue. In the control variant, underground organs accumulated 14.7% and aboveground organs 22% from the total P in the substrate. The D variant (3K) increased accumulation of underground organs (18.29%) and aboveground organs accumulated 39.30% from the total K in the environment.

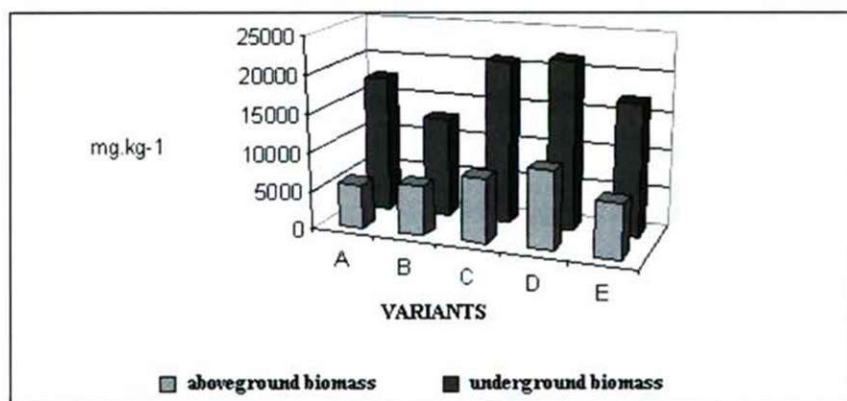


Figure 5 The amount of potassium (mg K.kg⁻¹ dry weight) in aboveground and underground organs of *Typha angustifolia* L.

The results of our experiments focused on the accumulation ability of the species *Typha angustifolia* L., acknowledge the fact that it works with Véber (1993) and Čížková (1994). Nitrogen, phosphorus and potassium are the macro elements that wetland plant species can accumulate in their organs in increased quantities and at a higher concentration. In the environment are also able to increase its income in the underground and aboveground organs of plants.

The results of our experiments, where we found the increase in accumulation capacity of plants in an increased supply of that element are also consistent with the findings of Šálek (1999). The vegetation is directly involved in the cleaning process by accumulation and

use of the nutrients released from the environment, particularly nitrogen, phosphorus and potassium and this gradually builds in its increased quantities of biomass.

The data presented in Table 3 show that plants of *Typha angustifolia* L. are able to receive and accumulate ions of salts in high concentrations and their use for production of biomass.

Table 3 The balance of nutrients (main macro elements) delivered in a nutrient solution to plants harvested after 21 days of cultivation

| The amount of available nutrients in mg | | | The amount of the element accumulated plant in mg | | |
|---|-----|------|---|-------|--------|
| N | P | K | N | P | K |
| 780 | 35 | 975 | 334,43 | 30,49 | 462,20 |
| 3900 | 35 | 975 | 345,22 | 24,28 | 319,80 |
| 780 | 105 | 975 | 276,07 | 30,59 | 532,60 |
| 780 | 35 | 4875 | 277,50 | 24,73 | 522,73 |
| 780 | 35 | 975 | 251,00 | 27,61 | 407,50 |

Legend: N – nitrogen, P – phosphorus, K – potassium

In an environment of increased concentrations of elements, the plants increased their accumulation and integrate them into their biomass. Nitrogen accumulated in plant biomass in the range of 32.18 to 42.88% of the amount available in solution. The plants were incorporated in the total biomass phosphorus in high quantities (69-87%). We have not seen any increased accumulation ability of plants to elevated concentrations of potassium (10.72%). The plants accumulated potassium in the primary concentration in the range (32.8 to 47.4%). We confirmed the synergistic effect of phosphorus in relation to potassium in the triple concentration of phosphorus (54.6%).

4. CONCLUSION

Based on the results of model experiments, which were obtained in the study of adaptive responses of species *Typha angustifolia* L. we can recommend the species of restoration processes in degraded ecosystems in semi terrestrial ecosystems in the alluvial farmland. We consider the use of the plants of its species in the restoration process for perspective. They function in the semi terrestrial ecosystems positively influencing eutrophic water treatment process to accumulate minerals in the agriculture landscape. Plants species *Typha angustifolia* L. are able to accumulate the major macro elements (nitrogen, phosphorus, potassium) and allocate them in the aboveground and underground biomass. *Typha angustifolia* L. is also hyperaccumulator of zinc (Zn), it is able to receive and accumulate of zinc ions in high concentrations. This species has high regeneration ability and is capable for vegetative propagation. It forms a large amount of biomass in the eutrophic and oligotrophic conditions and therefore has potential as an energy source.

We recommend to support the growth of macrophyte vegetation particularly species of *Typha angustifolia* L in the case of increased contamination of mineral elements in semi terrestrial ecosystems, where we demonstrate the ability to accumulate minerals from the substrate.

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REFERENCES

1. Agathos, S. N., Reineke, W. (2000): *Biotechnology for the Environment: Strategy and Fundamentals*. Dordrecht : Kluwer Academic Publisher, 2000. 459 p.
2. Bart, D., Hartman, J. M. (2000): Environmental determinants of *Phragmites australis* expansion in a New Jersey salt marsh: an experimental approach. In *Oikos*, Vol. 89, 2000, No. 1, p. 59-69.
3. Cronk, J. K., Fennessy, M. S. (2001): *Wetland plants: biology and ecology*. NY : Lewis Publishers, 2001. 462 p.
4. Cudlín, P. et al. (2001): Stress concept: Possible tool to study changes in landscape. In *Ekológia*, roč. 20, 2001, č. 1, p. 3-13.
5. Čížková, H. (1994): Potřebujeme v kořenových čistírnách rostliny? In Čížková, H. - Flek, S. - Husák, Š. (eds). *Kořenové čistírny a další vegetační systémy zlepšující kvalitu vod*. Třeboň : Bot. ústav AV ČR, 1994. p. 17 – 21.
6. Dercová, K., Makovníková, J., Barančíková, G., Žuffa, J. (2005): Bioremediácia toxických kovov kontaminujúcich vody a pôdy. In *Chem. listy*, roč. 99, 2005, p. 682-693.
7. Flek, S., Lukavská, J. (1994): Propagační leták. Třeboň : ENVI.
8. Hoagland, D. R. (1939): The water culture method for growing plants without soil. *Agr. Exp. Sta. Berkeley Cal. circ.* 347.
9. Chapin III., F. S., Matson, P. A., Mooney, H. A. (2002): *Principles of terrestrial ecosystem ecology*. NY : Springer science, 2002. 436 p.
10. Kovář, P. (2006): Ekologie obnovy poškozené krajiny. In Prach, K. et al. (eds). *Zprávy České botanické společnosti. Materiály 21. Botanika a ekologie obnovy*. Praha : Česká botanická společnost, 2006. 255 p.
11. Prasad, M. N. V., Strzalka, K. (2002): *Physiology and biochemistry of metal toxicity and tolerance plants*. Dordrecht : Kluwer Academic Publisher, 2002. 432 p.
12. Samways, M. J. (2000): A conceptual model of ecosystem restoration triage based on experiences from three remote oceanic islands. In *Biodiversity and conservation*, Vol. 9, 2000, No. 8, p. 1073-1083.
13. Swindoll, Ch. M., Stahl, R. G. (2000): *Natural remediation of environmental contaminants*. NY : Setac Press, 2000. 455 p.
14. Šálek, J. (1999): Navrhování a provozování vegetačních kořenových čistíren. *Metodiky pro zemědělskou praxi 2/1999*. Praha : Ústav zemědělských a potravinářských informací, 1999. p. 21.
15. Šásek, V., Glaser, J. A., Baveye, P. (2003): *The utilization of bioremediation to reduce soil contamination*. Dordrecht . Kluwer Academic Publisher, 2003. 417 p.
16. Véber, K. (1993): Dočišťování vod vyššími rostlinami. *Studijní správa. Rostlinná výroba*. Praha : Ústav zemědělských a potravinářských informací, 1993. 89 p.
17. Vise, D. L. et al. (eds). (2000): *Bioremediation of contaminated soils*. NY : Marcel Dekker Inc., 2000. 903 p.
18. Willey, N. (2007): *Phytoremediation: methods and reviews*. New Jersey : Humana Press, 2007. 478 p.